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THE QUEENSLAND JOURNAL OF AGRICULTURAL SCIENCE

VOL. 14. No. 1.
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OBSERVATIONS ON TOPDRESSING A COPPER-DEFICIENT PASTURE IN SOUTH-EASTERN QUEENSLAND

By R. D. CHESTER, B.V.Sc. (formerly Officer in Charge, Cattle Husbandry Branch), S. MARRIOTT, B.Sc.Agr. (Chief Agrostologist, Agriculture Branch), and J. M. HARVEY, D.Sc. (Biochemist, Biochemical Branch).

SUMMARY.

Trials were conducted in successive years to examine the effect of topdressing with copper sulphate, alone and in combination with superphosphate and with superphosphate plus lime, on the botanical and chemical composition of pasture and on the growth rate of grazing Hereford heifers.

The pasture was predominantly narrow-leaved carpet grass with limited amounts of paspalum and white clover. Only where soil treatments included ground limestone at 1 ton per acre was there a marked change in botanical composition of this pasture, white clover increasing to 33 per cent. of ground cover. Paspalum and white clover maintained higher average copper levels than narrow-leaved carpet grass in all treatments, including the control paddock.

Topdressing with copper sulphate at 14 lb. per acre at 6-monthly intervals was necessary to maintain an adequate copper status in grazing cattle.

Grazing cattle in the region show a stationary or declining weight during the winter months and increasing weight during summer and early autumn. There were no significant differences in weight between the experimental groups with respect to either summer-autumn gains or winter losses, indicating that copper deficiency is not the only factor limiting growth of cattle in this area.

All animals, including those from areas treated with superphosphate at 187 lb. per acre per annum, had an unsatisfactory blood inorganic phosphate during the winter months. This suggests that phosphate as well as copper may limit the growth rate of cattle on this property, and that heavier applications of superphosphate are required.

Parenteral copper therapy at 3-monthly intervals also maintained a satisfactory liver copper reserve in cattle grazing untreated pastures.

A pilot cobalt supplementation trial did not show a significant response in treated cattle but the supplemented group tended to make more satisfactory weight gains.

The cause of loss in weight in grazing cattle during winter and the syndrome of scouring and emaciation in certain wet winters when pasture appears adequate remain to be determined.

I. INTRODUCTION.

The property on which these observations were made is situated in south-eastern Queensland about 60 miles north of Brisbane and comprises about 3,000 acres. It carries approximately 1,000 head of mixed beef cattle, mainly bred on the property for sale as fatteners at about two years of age. The dominant pasture species is narrow-leaved carpet grass (*Axonopus affinis*). Paspalum (*Paspalum dilatatum*) and white clover (*Trifolium repens*) are present in limited quantities. A native sedge (*Carex appressa*) is abundant in some areas. Much of the land is subject to flooding and is badly drained.

Sutherland (1952) recorded the initial observations on this property. Serious losses occur in breeding cows and their calves and in yearlings, particularly in years when rainfall is high, the symptoms being marked scouring, emaciation and weakness. A diagnosis of copper deficiency was confirmed by the low levels of copper found in both blood and liver samples. Further confirmation of copper deficiency was obtained by a pilot trial, in which a clinical response occurred in animals receiving copper sulphate solution as a weekly drench.

II. 1951-53 TRIAL.

A field trial was initiated to study the effects of soil treatments on the pastures of the river frontage and on the animals grazing those pastures. Transect counts were used to assess changes in botanical composition, and variations in mineral composition of each pasture species were determined by chemical analyses. Hereford heifers were grazed on the treated pastures and their liveweights recorded.

(1) Methods.

Soil samples were taken with an iron auger, air-dried and prepared for analysis by grinding with pestle and mortar. Pasture samples were collected with stainless steel scissors, sorted into species by hand, then air-dried and milled in a laboratory mill containing no brass or copper parts.

Blood was drawn from the jugular vein, using stainless steel needles; the blood was collected in copper-free bottles containing potassium oxalate. Liver samples were taken by the liver biopsy technique of Loosmore and Allcroft (1951), using the instruments described by Dick (1944).

Copper in soil, pasture, blood and liver was determined by the method of Clare, Cunningham and Perrin (1945). The colorimetric procedure of Briggs (1922) was used in the analysis of phosphorus. The method of Dick and Bingley (1951) was used for the determination of molybdenum.

(2) Soil Type.

The soil of the area is a grey-brown loam of recent alluvial origin with poorly developed structure. Internal drainage is poor. It is acid in reaction

(pH 5·36) and has satisfactory potassium (replaceable K, m-equiv. per cent. = ·255) and nitrogen (0·19 per cent.) levels. Available phosphorus, however, is low, being 32 p.p.m. P_2O_5 in the top six inches. The total copper content ranges from 11 to 14 p.p.m.

(3) Experimental.

Twenty acres of this soil type on the river flats were surveyed into four paddocks, each of five acres. Soil treatments applied in March 1951 were kept to a minimum in order to reduce costs to a level commensurate with the form of land use adopted—breeding store cattle. The treatments were as follows:—

Paddock 1.—Copper sulphate 10 lb. per acre, ground limestone 1 ton per acre, superphosphate 187 lb. per acre.

Paddock 2.—Copper sulphate and superphosphate as for paddock 1.

Paddock 3.—Copper sulphate as for paddocks 1 and 2.

Paddock 4.—Untreated control.

Paddocks 1, 2 and 3 were renovated with tandem disc harrows and oversown in May 1951 with paspalum, red clover, white clover and lucerne. The red clover and lucerne did not become established.

Owing to drought and management difficulties it was not possible to complete the fencing and introduce experimental cattle to the paddocks until April 1952, 12 months after the initial topdressing. During this period, the rainfall was approximately 39 in., compared with the annual average of nearly 61 in. As more than half the actual rainfall was received in the three months immediately prior to the initial grazing, the wastage of lime and superphosphate through leaching would have been low.

Sixteen weaner Hereford heifers, divided into four groups of comparable age and weight, were maintained in the experimental paddocks from April 1952 to August 1953. All cattle were tuberculin tested and immunised against tetanus and blackleg at the commencement of the experiments. Cattle tick and worm burdens were kept at low levels by spraying with toxaphene and drenching with phenothiazine.

Soil samples were taken before the trial began. Routine examinations involved the collection monthly of pasture samples and quarterly of liver and blood samples. The experimental animals were weighed each month.

(4) Results.

The results are summarised in Table 1.

Pasture samples were taken from April 1952 to August 1953 following soil treatments in March 1951. Pasture from the topdressed paddocks showed a copper content slightly higher than that of the same species from the untreated area. The copper levels were higher in paspalum than in carpet grass. Molybdenum levels did not exceed 0·5 p.p.m. in either species.

Table 1.

Copper Concentration and Botanical Composition of Pasture and Liver Copper Concentration of Cattle—1951-53 Trial.

Paddock.		1.	2.	3.	4.
Pasture—					
Copper content (p.p.m. dry matter) (sampled monthly)—					
Carpet Grass	Range	5–8	5–8	5–10	4–6
	Mean	6·3	6·9	6·5	5·1
Paspalum	Range	7–12	7–12	7–12	5–10
	Mean	9·0	9·0	9·0	7·6
Botanical composition (percentage ground cover) in June, 1953—					
Carpet grass		88	93	98	96
Paspalum		3	5	2	1
Clover		9	2	0	3
Liver copper (p.p.m. dry matter)—					
April, 1952*	Range	14–38	23–125	21–74	30–90
	Mean	26	60	52	47
July, 1952		18	56	51	45
November, 1952		26	66	99	40
February, 1953		54	87	105	43
May, 1953		23	60	84	22
August, 1953	Range	15–18	16–190	27–90	14–42
	Mean	16	68	54	28

* Immediately before being confined in the experimental paddocks.

In June 1953, line transects showed that carpet grass remained the predominant species in all paddocks, paspalum represented only 1–5 per cent. and significant amounts of clover occurred only in paddock 1, presumably due to the lime treatment.

Liver copper concentrations in the experimental animals were not high (14–125 p.p.m.) at the commencement of the trial. In paddock 1 they showed an increase only at the ninth month (February 1953) and then declined to below the pre-treatment level at the 15th month (August 1953). The heifers in paddocks 2 and 3 showed a similar pattern, with maximum levels at the ninth month, while those in paddock 4 gradually declined during the trial.

The liveweight changes are presented in Fig. 1. They show the usual pattern for grazing cattle in this region (Near North Coast)—stationary or declining liveweight during the winter months (April to August) and increasing liveweight during summer and early autumn. Weight gains of the group grazing the untreated pasture tended to be lower, but significant differences between groups could not be detected with such small numbers of cattle.

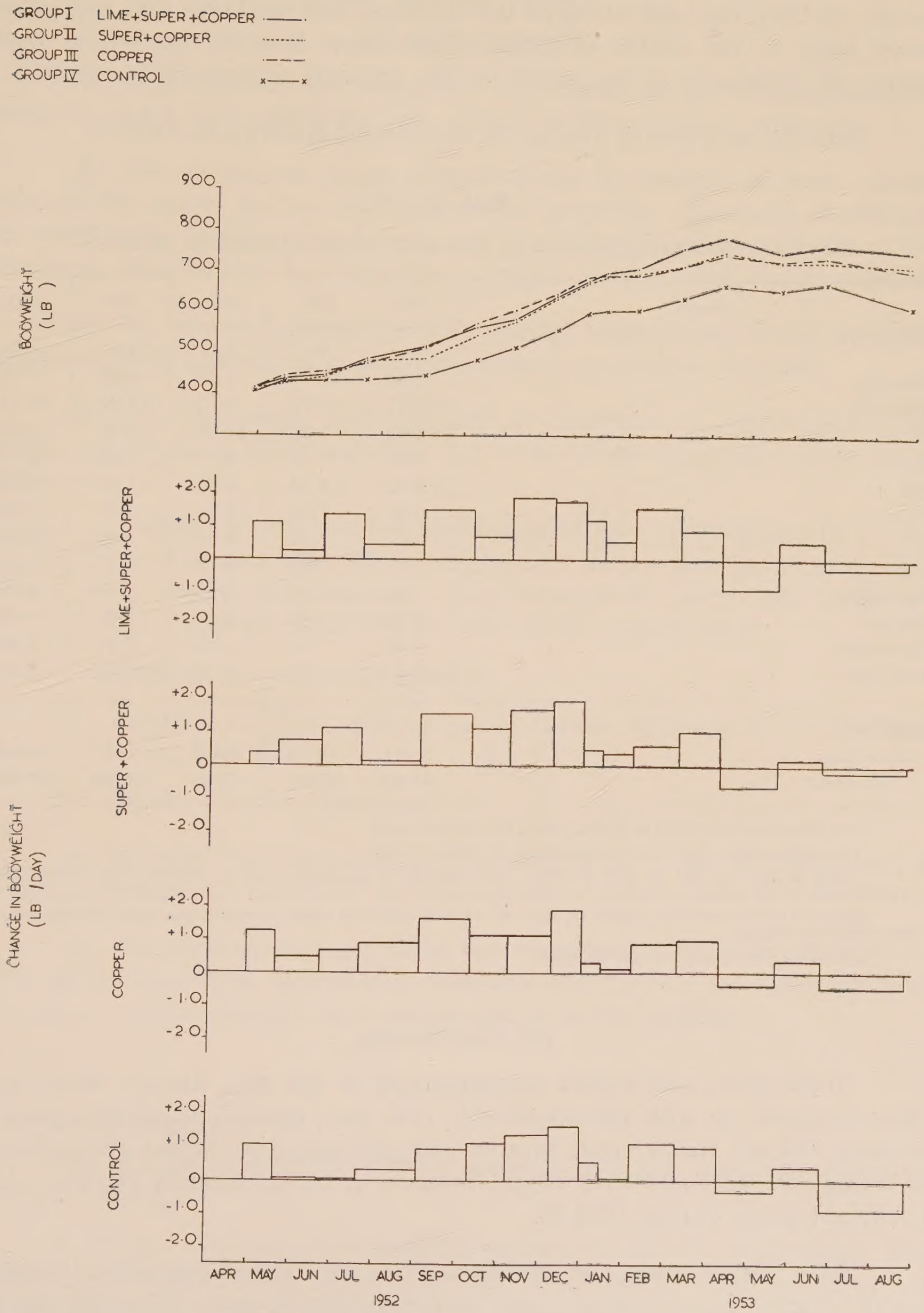

Fig. 1.

Mean Liveweight Changes in Hereford Heifers from Each Group During 1951-53 Trial.

Although all the experimental cattle lost weight during the winter months of 1953, they did not show the diarrhoea and weakness that had caused heavy losses in the winter of 1950. There were, however, no serious losses among the remainder of the cattle on this property during 1952 and 1953.

Rainfall each month during the experiment is shown in Table 2.

Table 2.

MONTHLY RAINFALL RECORDED AT DISTRICT OFFICIAL RECORDING STATION.

Month.	1950.	1951.	1952.	1953.	1954.
	in.	in.	in.	in.	in.
January	6·85	25·79	2·15	8·50	7·78
February	18·27	5·27	6·27	17·25	24·77
March	4·06	7·33*	11·55	8·25	6·03§
April	5·23	·38	3·57†	3·60	2·12
May	2·38	3·14	5·30	1·50	4·31
June	5·62	1·94	11·75	·20	2·68
July	9·47	·24	6·00	·43	12·60
August	3·91	·93	4·20	4·52	4·85
September	·42	·68	3·40	2·18‡	3·78‖
October	3·72	2·86	4·50	2·87	9·98
November	4·83	·23	·20	5·99	4·66
December	2·50	1·07	4·10	1·59	5·92
Totals—					
Apr.-Aug.	26·61	6·63	30·82	10·25	26·56
12 Months	67·26	49·86	62·99	56·88	89·48

* Soil treatments applied in March, 1951, for 1951–53 trial.

† Experimental heifers placed in paddocks for 1951–53 trial.

‡ End of 1951–53 trial on Sept. 2, 1953. Soil treatments applied on Sept. 5, 1953 for 1953–54 trial and experimental heifers placed in paddocks 1 week later.

§ Second soil treatments on Mar. 11, 1954, for 1953–54 trial and heifers removed from paddocks for seven days after topdressings.

‖ 1953–54 trial ended on Sept. 13, 1954.

(5) Conclusions.

Topdressing with copper sulphate at 10 lb. per acre, whether alone, with superphosphate or with superphosphate plus lime, applied 12 months prior to stocking, did not enable cattle grazing this predominantly carpet grass pasture to accumulate adequate liver copper reserves or to significantly improve their liveweight gains during 1952-53.

Both carpet grass and paspalum from the treated paddocks showed a slightly higher copper content than in the untreated area. Paspalum showed a higher copper concentration than carpet grass but represented only a small proportion of the pasture—less than 5 per cent. Only in the area treated with ground limestone was there an indication of change in botanical composition, white clover representing 9 per cent. of the pasture.

III. 1953-54 TRIAL.

(1) Experimental.

The 1953-54 trial was essentially a continuation of the previous trial, using the same four paddocks with certain modifications as follows:—

(1) Sixteen weaner heifers approximately six months old were selected from the 25 weaner heifers available on the property. The basis of selection was uniformity in age, type, weight and liver copper reserves. Seven of the remaining nine heifers were used for a copper therapy trial, described below.

(2) To control pasture growth during summer and early autumn, additional stock were added to each experimental paddock as required.

(3) Soil treatments were applied at intervals of approximately six months—on Sept. 5, 1953, and Mar. 11, 1954—to the same four paddocks, as follows:—

Paddock 1.—No further application of lime; superphosphate 187 lb. per acre plus copper sulphate 28 lb. per acre per annum. The superphosphate and copper sulphate were given in two applications of 93½ lb. and 14 lb. respectively.

Paddock 2.—As for paddock 1.

Paddock 3.—Two applications of copper sulphate as for paddocks 1 and 2.

Paddock 4.—No treatment.

(4) Monthly line transects were continued, as in the previous trial, to determine changes in botanical composition.

(5) The animals were placed in the experimental paddocks on Sept. 12, 1953, seven days after topdressing, sufficient rain having fallen to minimise the risk of copper toxicity from contamination of the pasture.

(2) Results.

(a) Pasture Copper.

The results of monthly pasture analyses and line transects are shown in Figs. 2 and 3.

Paddock 1.—Carpet grass absorbed copper quickly after topdressing. The copper concentration then fell sharply and three months after treatment had declined to a marginal to low level. Paspalum showed a less marked rise in copper and the subsequent fall was also less marked. Clover showed a similar pattern. Although carpet grass was dominant, the proportion of clover increased significantly in this paddock, due presumably to the initial application of ground limestone at 1 ton per acre in March 1951.

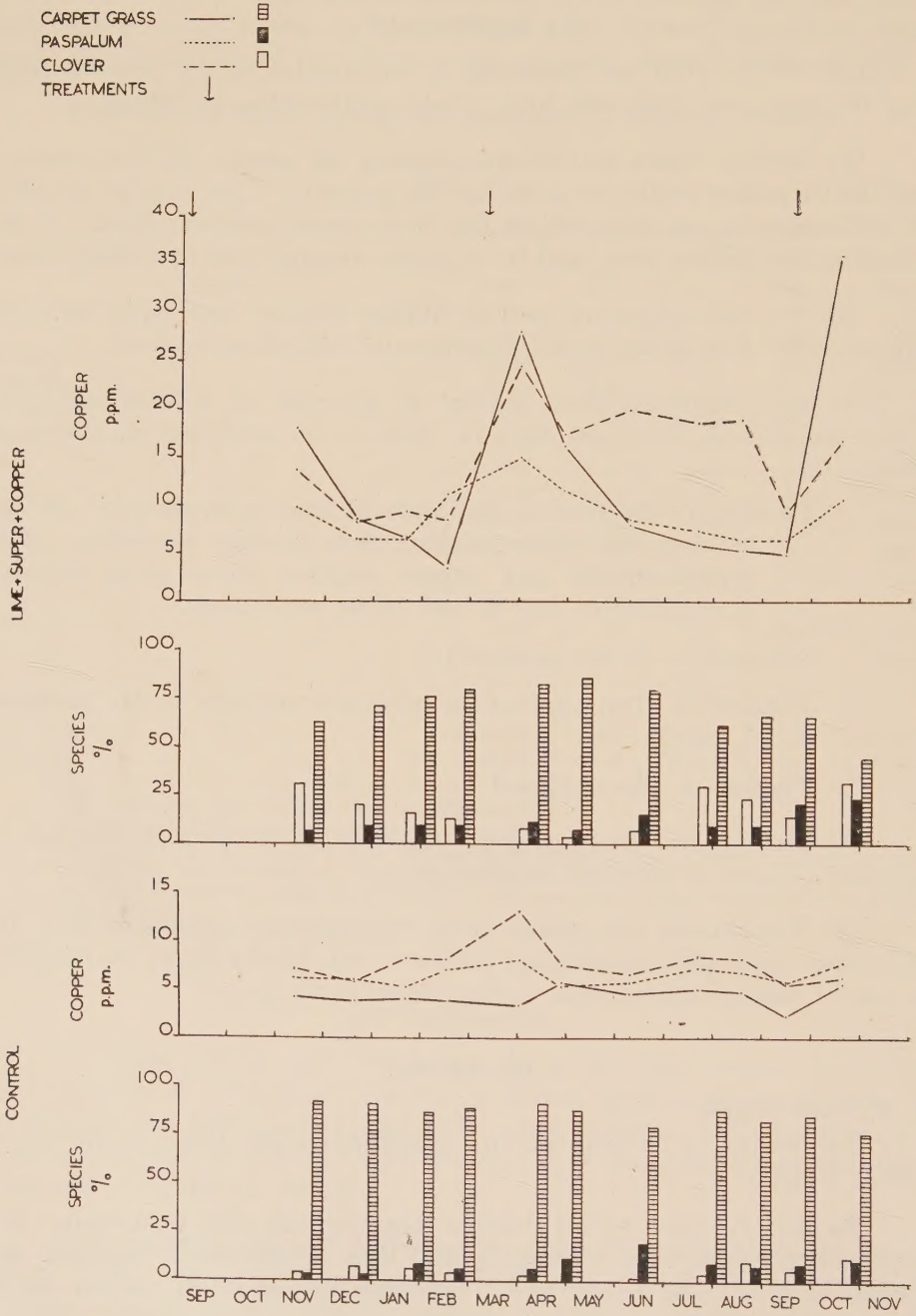

Fig. 2.

Copper Concentration and Botanical Composition of Pasture in Trial Paddocks 1 and 4 During 1953-54.

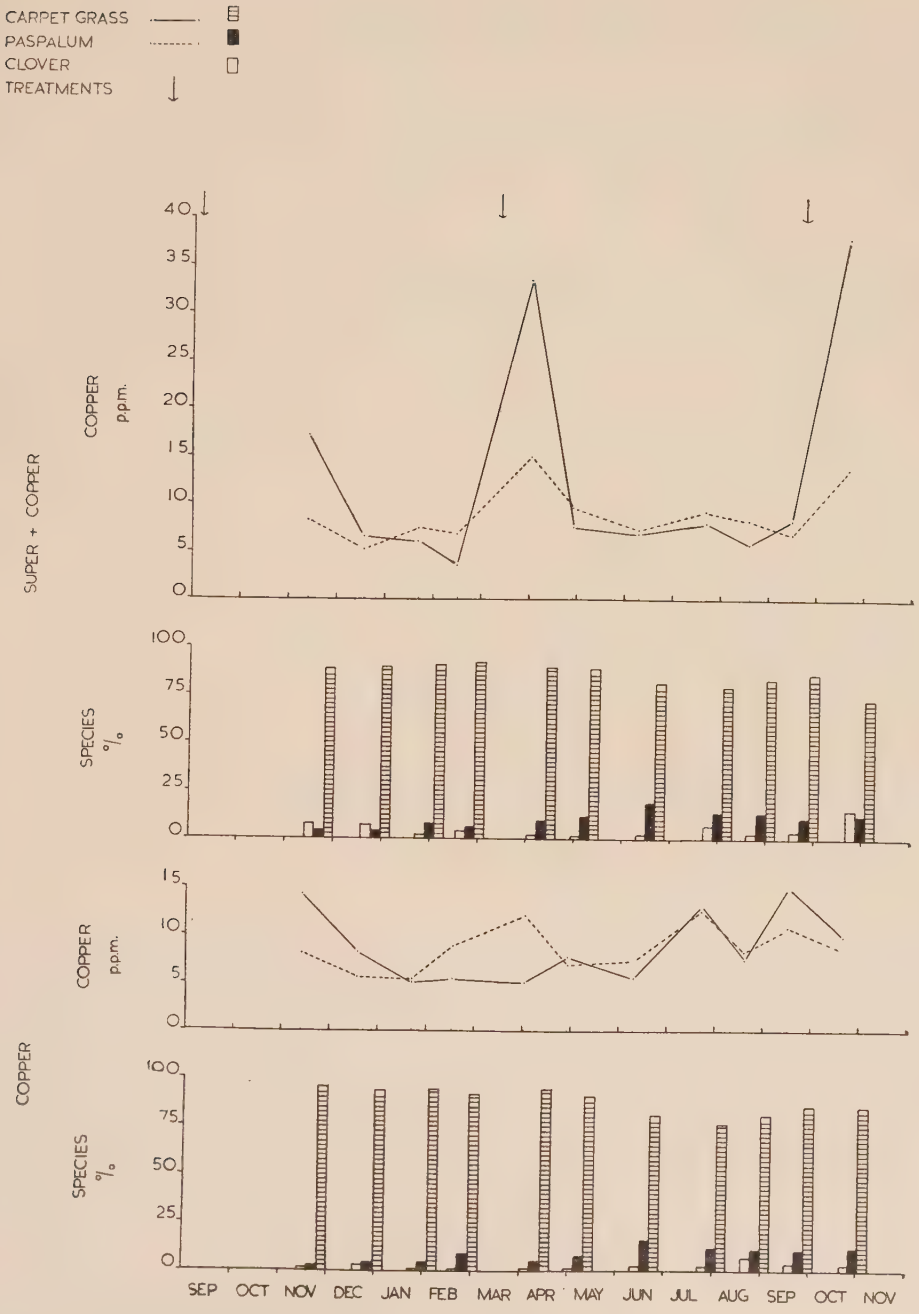

Fig. 3.

Copper Concentration and Botanical Composition of Pasture in Trial Paddocks 2 and 3 During 1953-54.

Paddock 2.—The pattern of copper uptake was similar to that in paddock 1. Carpet grass was dominant and the proportion of clover was low.

Paddock 3.—There was a less marked increase in the copper concentration in carpet grass following soil treatments. Here sawdust was used as a filler to distribute the copper sulphate. In paddocks 1 and 2, the superphosphate acted as the distributing agent for the copper sulphate. There is therefore an indication that for carpet grass, grown on soil where the available phosphate is low, additional phosphate may be necessary for maximum uptake of added copper sulphate. The initial uptake of copper by paspalum was similar to but less marked than in paddocks 1 and 2. Carpet grass was the dominant species, and the proportion of clover was negligible.

Paddock 4.—There were small seasonal variations in the copper content of pasture from this untreated area. Carpet grass was the dominant species. Its copper content was low, ranging from 2·5 to 5·5 p.p.m. Paspalum showed

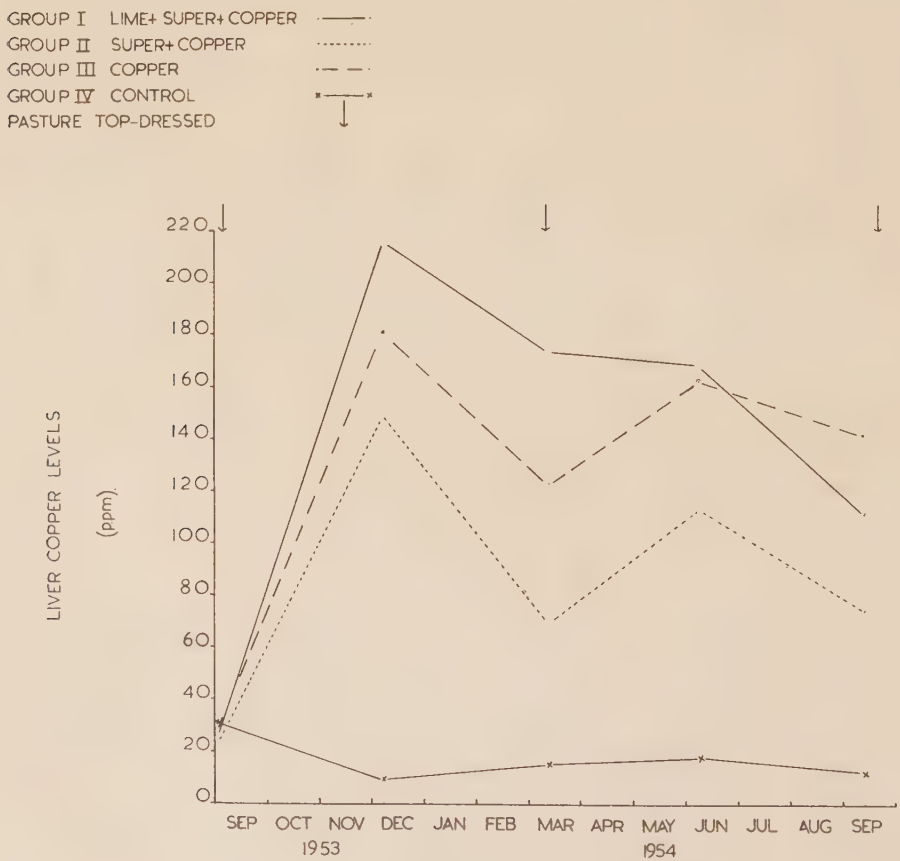

Fig. 4.

Mean Liver Copper Levels in Hereford Heifers from Each Group During 1953-54 Trial.

a slightly higher copper concentration (5–8 p.p.m.). Since the subdivision of this area in March 1951 an appreciable proportion of clover, ranging from 1 to 10 per cent., has been present in this paddock. This is greater than that recorded in paddocks 2 and 3 but considerably less than that found in paddock 1 (range 3 to 33 per cent.). The copper content of the clover varied from 6 to 13 p.p.m.

(b) Liver Copper.

Liver biopsy samples were taken at intervals of three months, the first samples being taken on Sept. 2, prior to topdressing on Sept. 5. The experimental animals were placed in their respective paddocks on Sept. 12.

The mean liver copper concentration of each group during the 1953-54 trial is shown in Fig. 4.

The liver copper concentrations were low in all experimental animals at the commencement of the trial, the range being 14 to 40 p.p.m. The animals grazing in paddocks 1, 2 and 3 showed a marked increase in liver copper concentrations at the December sampling and a decline at the March sampling. A further increase was shown at the June sampling following the second soil treatments on Mar. 11, 1954. The liver copper reserves had fallen again by September. Experimental animals from the control paddock showed an initial decline and for the ensuing nine months maintained a rather constant low level.

It is apparent, therefore, that under the seasonal conditions experienced the application of 14 lb. copper sulphate per acre at intervals of six months will maintain adequate copper reserves in grazing cattle.

(c) Pasture Phosphate.

The data from pasture phosphate analyses are presented in Fig. 5. Paspalum showed a higher phosphate content than carpet grass. There was a seasonal variation in the phosphate concentration in both species. In spite of topdressing with superphosphate, carpet grass in paddocks 1 and 2 showed a marginal to low phosphate status at the March-April sampling. In the untreated paddock (No. 4) carpet grass was deficient in phosphate at the January-February and March-April samplings. The phosphate level was good in the clover samples.

(d) Blood Inorganic Phosphate.

Blood inorganic phosphate analyses were made at intervals of three months on all animals from the experimental paddocks and on seven heifers of comparable age which were not confined to the trial area (see the copper therapy trial described below). The results are shown in Table 3.

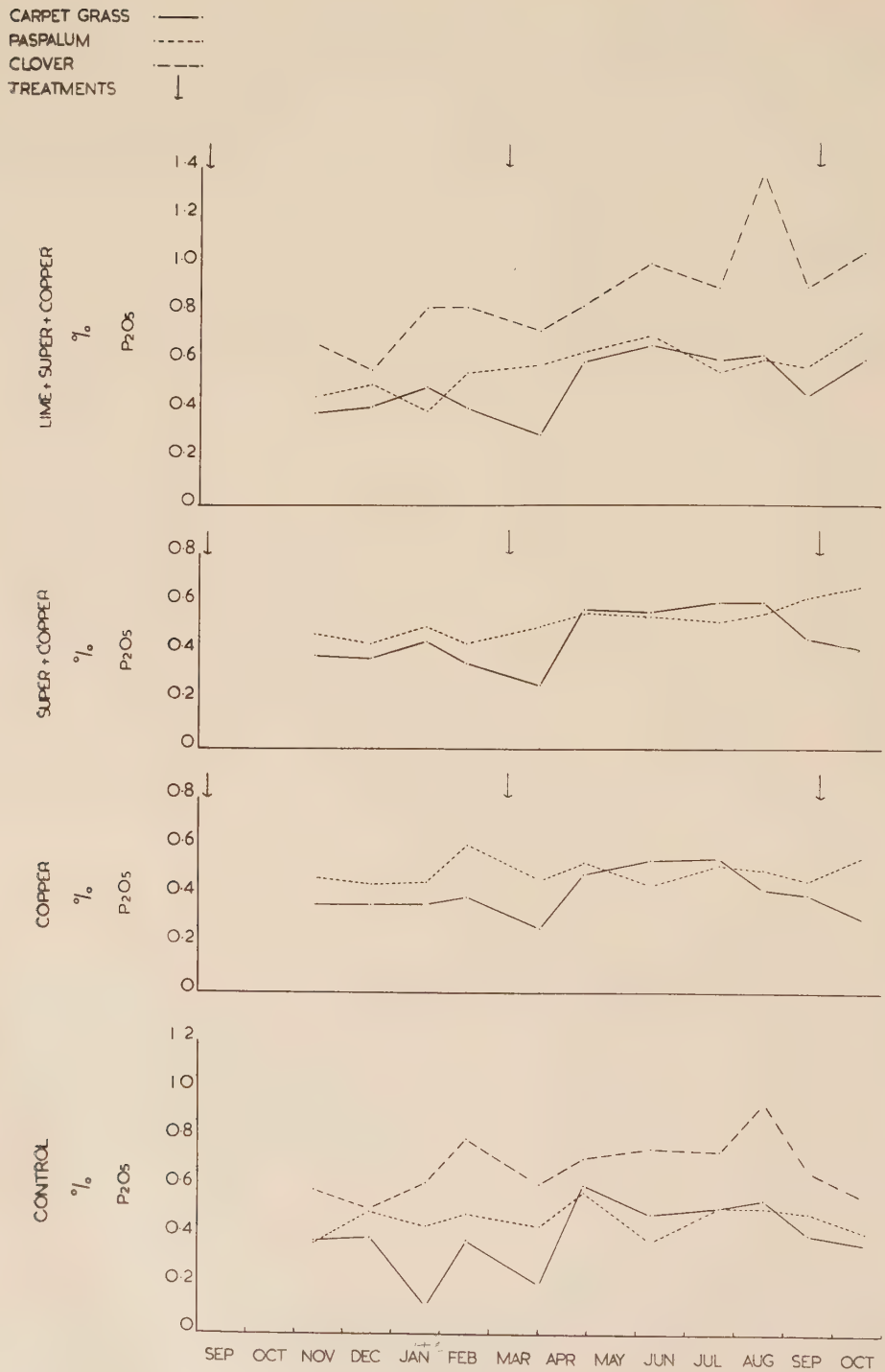

Fig. 5.

Phosphate Content of Pasture in Trial Paddocks During 1953-54.

Table 3.

BLOOD INORGANIC PHOSPHATE LEVELS IN HEREFORD HEIFERS DURING 1953-54 TRIALS.
(mg. P/100 ml.)

Sampling Date.	Paddock 1.		Paddock 2.		Paddock 3.		Paddock 4.		Outside Heifers—Copper Therapy Trial.	
	Range.	Mean.	Range.	Mean.	Range.	Mean.	Range.	Mean.	Range.	Mean.
Jan. 26, 1954	4·8–6·0 (0) *	5·4	4·7–6·2 (0)	5·4	4·1–5·1 (0)	4·8	4·1–4·7 (0)	4·7	..	..
Mar. 12, 1954	3·6–4·4 (1)	4·1	3·8–4·7 (1)	4·3	3·2–4·2 (3)	3·7	3·6–4·4 (1)	4·1	3·6–5·5 (2)	4·3
June 10, 1954	3·5–4·7 (1)	4·2	3·3–4·1 (2)	3·8	3·5–5·5 (2)	4·4	2·8–4·4 (1)	3·9	3·6–4·3 (5)	3·8
Sept. 13, 1954	3·3–4·0 (3)	3·5	3·4–4·5 (2)	4·3	3·9–4·8 (1)	4·4	2·8–5·2 (2)	3·8	3·9–5·2 (1)	4·6

* Figures in brackets indicate the number of animals from each group showing blood inorganic phosphate levels less than 4·0 mg. P/100 ml.

The blood inorganic phosphate status was satisfactory in January, but marginal to low in some animals from each group at the March, June and September samplings. It would therefore appear that for this predominantly carpet grass pasture, annual topdressing with 187 lb. superphosphate per acre does not ensure an adequate phosphate status in grazing cattle.

The annual applications of 187 lb. superphosphate were given to avoid expense on land used only for breeding. It is now known that heavy applications of superphosphate (1,120 lb. per acre) may give major changes in clover growth on the south-eastern coast of Queensland, and that these applications may remain effective for at least three years.

In animals from outside the experimental paddocks, phosphate deficiency was particularly evident in June, when five out of six animals examined showed borderline to low blood inorganic phosphate levels.

(e) Blood Haemoglobin.

This was recorded at intervals of three months. The mean levels in grams per 100 ml. of blood from experimental animals ranged from 12·1 to 12·7 in paddock 1, 11·8 to 9·9 in paddock 2, 11·8 to 9·3 in paddock 3 and 11·0 to 10·2 in paddock 4. Thus there was no correlation between haemoglobin levels and liver copper reserves.

(f) Rainfall.

The monthly rainfall during the experimental period is shown in Table 2. This was an unusually wet year with maximum falls in February and July, when 24·77 and 12·60 in. were recorded. Flooding of the experimental paddocks followed the February rains, necessitating the removal of all experimental heifers for two weeks.

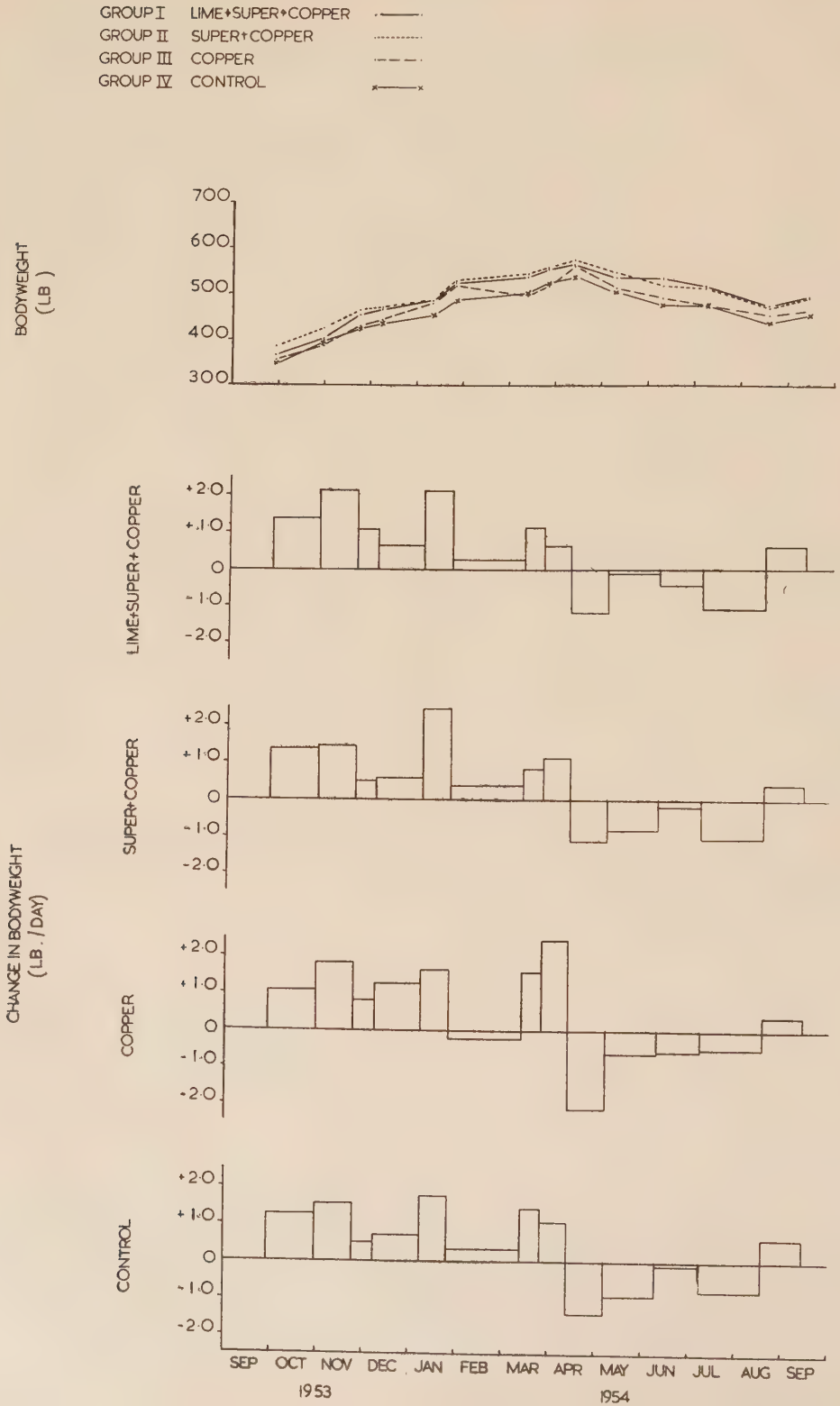

Fig. 6.

Mean Bodyweight Changes in Hereford Heifers from Each Group During 1953-54 Trial.

(g) Liveweight.

The liveweights of the experimental heifers are shown in Fig. 6. During the 12 months of the experiment the increases ranged from 360 lb. to 475 lb. The mean daily gains for the groups were:—

Group 1—0·38 lb. per head per day.
Group 2—0·31 lb. per head per day.
Group 3—0·32 lb. per head per day.
Group 4—0·30 lb. per head per day.

The heifers gained weight from the commencement of the trial until April, lost weight until August and had started to gain weight in September. It is evident that there is no difference between groups with respect to either summer-autumn gains or winter losses. Since the three groups grazing topdressed paddocks had normal liver copper concentrations, whereas group 4 was deficient, it is concluded that copper deficiency is not the only factor limiting the growth of cattle on this property.

The blood inorganic phosphate status was unsatisfactory in all groups from March to September, 1954, so deficiency of phosphate as well as copper could play some part in limiting growth of cattle on this property.

Ample and well distributed rain during 1954 resulted in above-average growth of pasture for this area, but it was observed that cattle grazed very little, at least during the day, during the period April to August. Quantitative observations on grazing times, feed intakes and yields of pasture dry matter were not made, but from inspection of the pastures and the cattle, one could not escape the conclusion that failure to consume the available pasture was an important cause of the pronounced loss in weight of the experimental heifers during winter and early spring. The syndrome of scouring, emaciation and weakness, that caused heavy losses in the wet winter of 1950, was prevalent in 1954 in the herd outside the experimental paddocks, where it again caused losses among cows, calves and yearlings. It has yet to be determined why, during apparently favourable seasons, cattle should show reduced appetite and exhibit this syndrome.

(3) Conclusions.

Topdressing with copper sulphate at 28 lb. per acre per annum in two applications each of 14 lb. per acre at intervals of six months enables grazing cattle on this predominantly carpet grass pasture to accumulate and maintain adequate liver copper reserves.

Carpet grass shows a marked increase in copper concentration following soil treatment in paddocks 1 and 2, where superphosphate was applied with the copper sulphate. This level also falls sharply. Paspalum shows a less marked but more prolonged rise, so residual copper concentrations tend to be higher in

this species. Clover shows a similar pattern. In paddock 3 the increases in copper concentration in both carpet grass and paspalum are less marked, but the raised copper levels tend to persist longer.

As in the 1951-53 trial, the proportion of clover is greatest in paddock 1, ranging from 31 per cent. in November to 3 per cent. in April and up to 30 per cent. in June. This may be attributed to the lime applied in March 1951. In paddock 2 the proportion of clover ranged from 1 to 15 per cent. Paddock 3 had from 1 to 3 per cent. and paddock 4 from 2 to 10 per cent. clover.

Soil treatments with lime, superphosphate and copper, alone or in combination, did not improve weight gains of heifers grazing this pasture during 1953-54. All groups showed marked weight losses during the period April to September. It would therefore appear that copper deficiency, which is evident from the low copper levels in livers from animals in the untreated control paddock 4, is not the only factor limiting the growth of cattle on this property.

Blood inorganic phosphate analyses indicate an unsatisfactory phosphate status in cattle from March to September. Even in the phosphate-treated paddocks 1 and 2, the phosphate content of the predominant carpet grass would be inadequate in the March-April period. It is therefore possible that phosphate as well as copper deficiency could be a factor limiting the growth of cattle on this property from April to September.

Observations on experimental heifers as well as pastures suggest that failure to eat the available pasture is an important cause of the pronounced loss in weight of the animals during winter and early spring. As in 1950, there were heavy losses in cattle outside the experimental paddocks. It would appear that the syndrome of scouring, emaciation and weakness, which in 1950 led to the initiation of these trials, may be a feature in years of unusually high winter rainfall in this locality.

IV. SUPPLEMENTARY TRIALS IN 1953-54.

(1) Copper Therapy Trial.

Seven heifers remaining after selection of the 16 heifers for the previous trial were divided into two groups. Three animals received 50 mg. copper subcutaneously as copper glycinate (aminoacetate) and four animals were treated intravenously with 25 mg. copper as copper sulphate. Treatments were repeated at intervals of three months and in the latter group the dose was subsequently increased to 50 mg. copper. The animals were allowed to run with the remainer of the herd on this property. At intervals of three months they were mustered for liver biopsy, weighing and retreatment.

(a) Results.

Liver copper levels in the copper glycinate group averaged 70 p.p.m. at the commencement of the trial and 85 p.p.m. at its conclusion 12 months later. Liver copper levels in the copper sulphate group averaged 70 p.p.m. at the beginning and 170 p.p.m. at the end of the period. This initial average of 70 p.p.m. was considerably higher than the initial average in heifers in the 1953-54 trial. It was due to parenteral copper therapy in some animals prior to the commencement of the supplementary trial.

Blood phosphate levels were unsatisfactory in some animals at the March, June and September samplings (Table 3). In June, five out of six animals tested showed marginal to low blood inorganic phosphate levels.

Liveweight changes for each group are shown in Fig. 7.

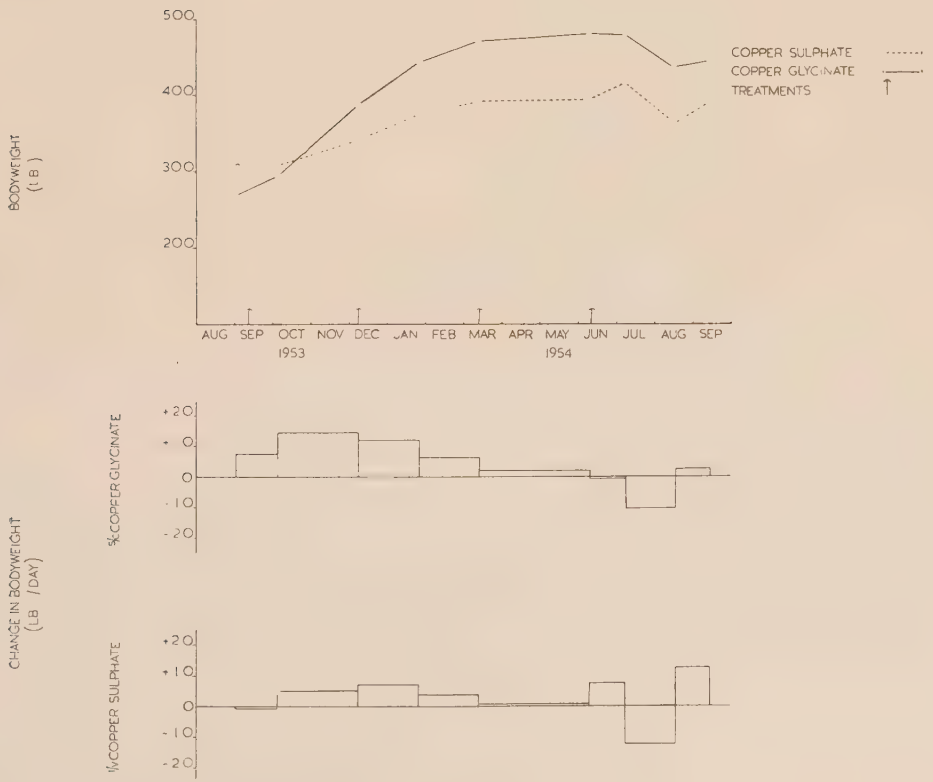

Fig. 7.

Mean Bodyweight Changes in Hereford Heifers from Copper Therapy Trial.

(b) Conclusion.

For these animals and for this season, treatment with parenterally administered copper every third month was sufficient to maintain adequate liver copper reserves. Weight gains were not satisfactory, particularly during the later months of the trial; they showed a pattern similar to that of the heifers in the four experimental paddocks described above.

It is apparent that, as in the previous trial, copper deficiency alone is not the factor limiting the growth of cattle on this property.

(2) Pasture Topdressing Trial.

Ten plots of pasture, each ½ square chain in area, were selected adjacent to the four experimental paddocks. The following treatments were laid down in duplicate on Sept. 5, 1953:—

(*a*) Treatment with calcium, phosphorus, and trace elements, viz.:

	lb. per acre
Ground limestone	2,240
Superphosphate	112
Borax	1½
Copper sulphate	14
Zinc sulphate	7
Manganese sulphate	14
Magnesium sulphate	56

(*b*) As for (*a*) but without limestone.

(*c*) Superphosphate 224 lb. per acre, plus copper sulphate 14 lb. per acre.

(*d*) Superphosphate 224 lb. per acre plus copper sulphate 28 lb. per acre.

(*e*) Copper sulphate 56 lb. per acre.

The pasture was similar to that in the adjoining experimental paddocks already described—i.e. predominantly narrow-leaved carpet grass with 1–5 per cent. paspalum. The amount of clover was negligible. From each plot a single sample of pasture was collected and hand-sorted into species. Samples were taken monthly from Nov. 12.

(a) Results.

The results of copper analyses are shown graphically in Fig. 8. The copper concentration in each pasture species from each treatment is the mean of two levels obtained from samples from the duplicate plots.

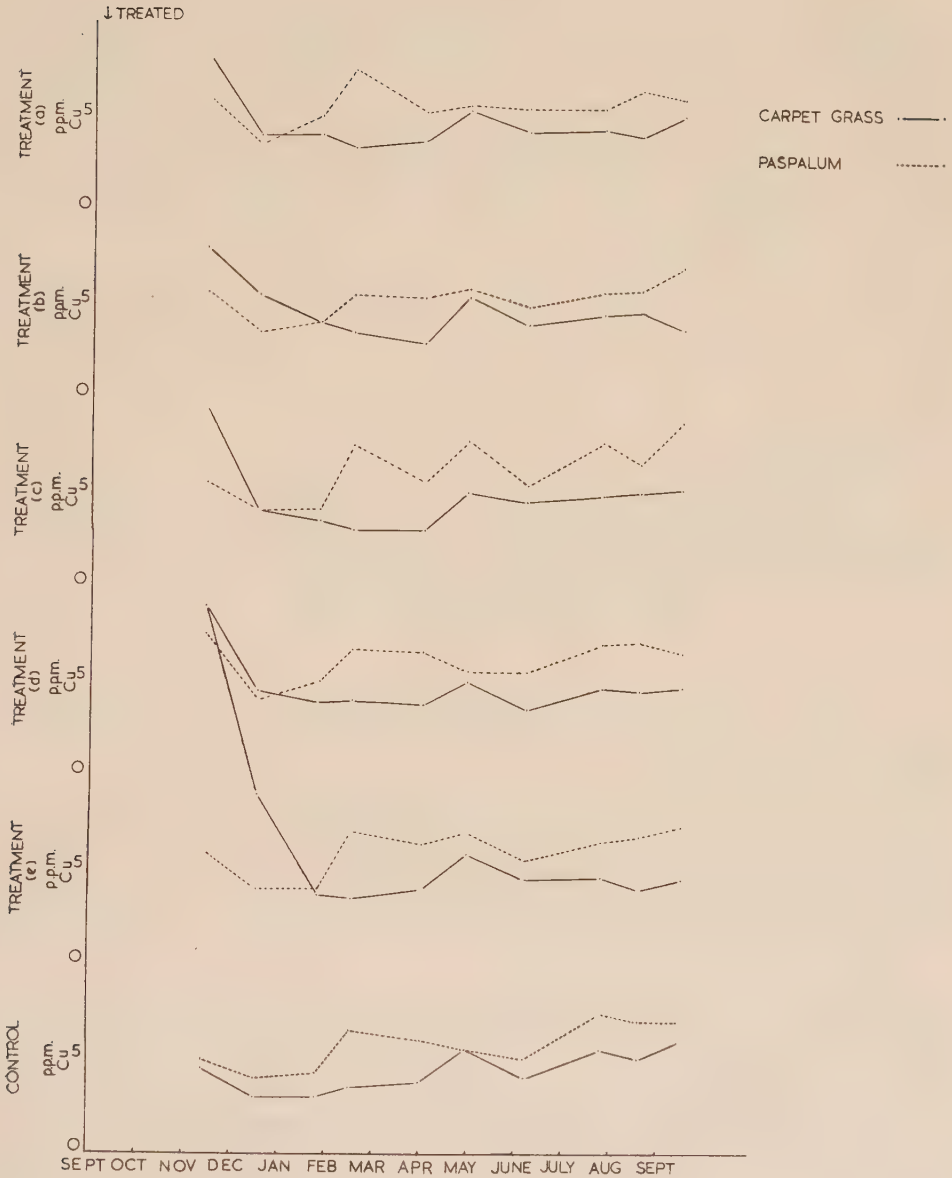

Fig. 8.

Copper Content of Carpet Grass and Paspalum from the Supplementary Pasture Topdressing Trial.

The copper concentration in carpet grass and in paspalum from these plots showed a pattern similar to that of pasture in the experimental paddocks already described. There was an increase in the copper content of carpet grass from the treated areas at the November sampling, two months after treatment.

This increase was most marked where the treatment was 56 lb. copper sulphate per acre (plot e). In December, the copper concentration in the carpet grass had fallen in all except plot e to a level comparable with that found in carpet grass from the untreated areas. In January and at all subsequent samplings until the end of the trial in September, the copper concentration in carpet grass was low irrespective of soil treatment. A similar pattern was shown by paspalum, except that the increase in copper concentration at the November sampling was less marked.

These experimental pasture plots were not grazed. The pasture management, therefore, did not favour the growth of clover. The duration of the trial was only 12 months. No significant changes in botanical composition were noted.

(b) Conclusion.

For this area the response from copper treatment, in terms of copper content of carpet grass or paspalum, does not persist for longer than four months, irrespective of the amount of copper sulphate added (up to 56 lb. per acre). Where copper sulphate was added at 14 lb. or 28 lb. per acre an increase in copper content of the predominant pasture could not be detected at sampling three months after treatment.

The fertilizer treatment with calcium, phosphorus and trace elements (plot a) did not influence the availability of added copper two and three months after topdressing.

The data from this trial, together with those from the 1953-54 grazing trial, support the conclusion that soil treatment with copper sulphate at the rate of 28 lb. per acre per annum applied in two topdressings six months apart is necessary to maintain an adequate copper status in cattle grazing on this property.

This rate and frequency of topdressing is heavy in comparison with that found necessary in other copper-deficient areas. In South Australia, topdressing with copper sulphate at the rate of 7 lb. per acre per annum is recommended (Marston 1951). In New Zealand, Cunningham (1951) stated, the most satisfactory method of control is topdressing with 5 lb. copper sulphate per acre each autumn. Gilbert (1952), in reviewing the data on residual effect of added copper on different soil types, stated that copper applications must be made more frequently on heavier soils and on sandy soils subject to excessive leaching. Teakle (1942) showed that when as little as 3 to 10 lb. of copper sulphate per acre was applied on sandy soils in Western Australia, it was unnecessary to add further copper sulphate for at least another year.

The necessity for heavy and frequent topdressing with copper sulphate to ensure an adequate copper status in grazing cattle on this property may be related partly to poor retention of copper by the dominant pasture species

(*Axonopus affinis*) and partly to the high rainfall (averaging 69.8 in. per annum for the three years of the trial) in an area where the soil structure is poorly developed.

(3) Cobalt Therapy Trial.

At the conclusion of the 1953-54 trial in September, the 16 heifers were paired as well as possible in terms of weight. One member of each pair was dosed by mouth with 2 fl. oz. of a solution containing 2 oz. cobalt chloride per gallon. Treatment was given twice during the first week and thereafter weekly. Liveweights were recorded fortnightly. The duration of the trial was eight weeks.

Liveweight differences did not permit a satisfactory pairing of animals, and there was a large within-group variation which vitiated statistical analyses. The mean weight gain for the cobalt-supplemented group for the trial period of eight weeks was 81 lb. (range 56-102 lb.) and for the untreated control group 62 lb. (range 16-89 lb.). This trend in favour of the cobalt-supplemented group warrants further investigation, particularly during the winter months, when stock on this property lose weight.

V. GENERAL CONCLUSIONS.

The main findings from the trial on this property are as follows:—

(1.) Topdressing with copper sulphate every six months at the rate of 14 lb. per acre is necessary to ensure an adequate copper status in grazing cattle. This is an unusually high requirement and may be related partly to the poor retention of copper by the predominant pasture species (narrow-leaved carpet grass) and partly to the high annual rainfall in an area where the soil structure is poorly developed.

(2.) Narrow-leaved carpet grass shows a large (up to 30 p.p.m. Cu) and rapid uptake of copper following topdressing with copper sulphate plus superphosphate. There is also a rapid decline in copper content.

(3.) The addition of copper sulphate at the rate of either 28 lb. or 56 lb. per acre does not give a longer persistence of copper in carpet grass than that obtained from topdressing with 14 lb. per acre.

(4.) Paspalum and white clover growing on the same soils under the same conditions maintain a higher average level of copper than narrow-leaved carpet grass. The very low proportion of these species in the pasture prevents them from making any significant contribution to the animals' diet.

(5.) The data on liveweight show that cattle with adequate liver copper gained no better in summer-autumn and lost no less in winter than the copper-inadequate control animals.

(6.) All animals had an unsatisfactory blood inorganic phosphate status, particularly during the winter months.

(7.) Topdressing with superphosphate at the rate of 187 lb. per acre per annum did not markedly improve the blood inorganic phosphate status in cattle grazing this pasture.

(8.) Liver copper reserves were maintained in Hereford heifers weighing 300 lb. by injections of 50 mg. copper as glycinate subcutaneously or as sulphate intravenously every three months.

(9.) Only in the area on which ground limestone was applied at 1 ton per acre was there any marked change in the botanical composition of the pasture. Here up to 33 per cent. white clover was found associated with the predominant narrow-leaved carpet grass.

(10.) Cobalt-supplemented cattle during the period September-November tended to make more satisfactory weight gains than untreated animals.

VI. ACKNOWLEDGEMENTS.

The authors wish to acknowledge their indebtedness to the owner of this property, who provided facilities, experimental animals and help in the carrying out of the work; to Mr. A. K. Sutherland, B.V.Sc., M.S. for valuable guidance in the course of these trials, the collection of the liver biopsy samples and considerable help in the preparation of this manuscript; to Mr. G. I. Alexander, B.V.Sc., and other officers of the Cattle Husbandry Branch; to Mr. A. Hegarty, who collected the pasture samples and line transect data and arranged the fertilizer applications; and to officers of the Biochemical Section who helped in the chemical analyses.

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A SURVEY OF THE INCIDENCE OF COPPER DEFICIENCY IN DAIRY CATTLE IN COASTAL QUEENSLAND SOUTH OF BRISBANE.

By G. I. ALEXANDER, B.V.Sc. (Senior Husbandry Officer, Cattle Husbandry Branch), and J. M. HARVEY, D.Sc. (Biochemist, Biochemical Branch), Division of Animal Industry.

SUMMARY.

Copper deficiency in dairy cattle has been diagnosed over most of the lower watersheds of Queensland rivers south of Brisbane by analysis of livers from slaughtered animals. Blood copper concentrations were also used as an index for a few properties from which livers were not available. Samples were obtained from 127 properties, of which 95 were copper deficient.

There is a correlation between the distribution of alluvial soils in this area and the incidence of copper deficiency in cattle. It is postulated that the low fertility of these alluvial soils and the dominance of narrow-leaved carpet grass (Axonopus affinis) **may account for this correlation.**

I. INTRODUCTION.

Lee and Moule (1947) first drew attention to the presence of copper deficiency in livestock in Queensland, indicating that it was widespread and of some economic importance in sheep-raising areas.

Harvey (1952) reviewed data on the extent and distribution of copper deficiency in both sheep and cattle areas of the State. He used two main criteria to assess the incidence of copper deficiency in sheep, viz., the characteristic and specific wool lesion, "straight or steely" wool, and the copper concentration present in both liver and blood.

Where cattle are concerned, no single clinical symptom is recognized as specific for copper deficiency. Confirmation of deficiency depends on biochemical analysis. Blood copper levels are a useful indication but liver copper concentration is more satisfactory as it shows the copper reserves in the animal.

Using these criteria, Harvey (1952) defined 11 localities in Queensland where copper deficiency in cattle occurs. One of these is the coastal area south of Brisbane. The river flats in this area are largely devoted to dairying. Although the lower reaches of the rivers receive an average annual rainfall of about 40 in., portion of the catchment receives as much as 80 in. per annum, and extensive flooding occurs during the wet season in many years. Near the mountain ranges, dairy-farmers grow forage crops for their cows, but nearer the coast, the arable land is devoted to cash crops rather than forage crops.

With a dairy cow population of approximately 40,000 on 750 farms, this area is one of the chief centres of milk supply for Brisbane. Production per cow, however, is not satisfactory, being the lowest of all districts contributing to the Brisbane milk supply. It is also low when compared with production in other dairying districts of the State. Pegg (1956) reported that the average production per cow for all cows in herd recording groups in Queensland during 1954-55 was 3,486 lb. milk, equivalent to 150 lb. butterfat. During this same period the average production per cow for two herd recording groups in south coastal Queensland was 2,783 lb. milk, equivalent to 112 lb. butterfat, and 2,679 lb. milk, equivalent to 112 lb. butterfat.

A wasting disorder, often associated with severe scouring, is seen even in periods of good pasture growth. Deaths of cattle suffering from this disorder have been recorded. Infertility is a problem and on some properties there has been a high incidence of brucellosis. Losses of calves and young growing stock are so high that on many properties the maintenance of herd numbers is only possible by the introduction of adult cattle. The incidence of parasitic gastro-enteritis in one portion of this area was described by Roberts, O'Sullivan and Riek (1952), who stated that mineral or trace element deficiency, if they exist, could play an important part in the host's susceptibility.

The operation in the area of a tuberculin testing programme, which included the destruction of all positive reactors, presented an opportunity for the collection of material at autopsy. A detailed survey of the incidence of copper deficiency in dairy cattle within this area could thus be made. The results of this survey are presented below.

II. METHODS AND MATERIALS.

Positive reactors to the tuberculin test were killed under supervision. A portion of the liver was collected from animals whose livers showed no macroscopic abnormalities. Where a large number of reactors came from one property, liver sampling was limited to six animals.

On several properties all the cattle tested gave a negative reaction to the tuberculin test. Some of these properties were visited subsequently and blood samples taken for copper analysis. Using stainless steel needles washed in glass-distilled water, blood was drawn from the jugular vein into copper-free bottles containing potassium oxalate. Copper was determined in both liver and blood, using the method of Clare, Cunningham and Perrin (1945).

III. RESULTS.

The results are shown in Table 1. The area has been divided into three zones marked 1, 2 and 3, which represent districts covered by each of the three veterinarians carrying out the tuberculin tests. Liver copper

concentrations of less than 30 p.p.m. were classed as copper-deficient; blood copper levels of 0·05 mg. or less per 100 ml. were considered indicative of copper deficiency (Cunningham 1946).

Table 1.

Analysis of Farms on the Basis of Copper Deficiency.

Zone.	Farms in Zone.	Farms Represented in Tests.	Copper Deficient Farms.		Farms Not Copper Deficient.	
			Number.	Per cent.	Number.	Per cent.
1	311	34	23	67·6	11	32·4
2	223	53	37	70·0	16	30·0
3	210	40	35	87·5	5	12·5
Totals	744	127	95	74·8	32	25·2

Table 1 shows that there is a high incidence of copper deficiency in grazing cattle in the area. Low liver or blood copper levels were found in cattle from 95 of the 127 farms examined. Fig. 1, which shows the distribution of these properties, indicates that there is a close relationship between copper deficiency in cattle and alluvial soils in this area.

IV. DISCUSSION.

Skerman (1952) mapped the alluvial soils of south-eastern Queensland. He described those in the area covered by this survey as being derived from tertiary basalts of the main range in the hinterland. These soils are periodically inundated by floods and drainage is a serious problem. They range from acid to strongly acid in reaction and are of low fertility. This, together with poor pasture management, has led to the invasion of sown pastures of paspalum (*Paspalum dilatatum*) and white clover (*Trifolium repens*) by narrow-leaved carpet grass (*Axonopus affinis*). White clover has persisted rather more than paspalum, but both are now dominated by the more aggressive carpet grass. This is particularly true in the alluvial areas towards the mouths of rivers, where drainage is a major problem.

Chester, Marriott and Harvey (1956) showed that narrow-leaved carpet grass has a lower copper content than paspalum and white clover grown on the same soil type and in the same locality about 60 miles north of Brisbane.

There are some anomalies which appear to contradict the general correlation between the distribution of copper deficiency and alluvial soils in this area. On a few properties the original sward of paspalum and white clover

has been maintained by careful pasture management. Other isolated cases of normal copper values in liver and blood of animals have been attributed to (*a*) the use of bought concentrates and roughages as supplementary feeds, (*b*) the use of relief country in non-deficient areas, and (*c*) introduction of cattle from other districts as replacements to maintain herd numbers.

Fig. 1.

Map Showing Distribution of Properties from Which Samples Were Taken. The shaded portions indicate alluvial areas.

O Normal Levels for blood or liver copper.

Δ Low levels for blood or liver copper.

There is little precise information on the effect of copper deficiency on either total milk production or butterfat content of milk. This study may indicate some relationship, as the dairy cattle in this area are among the lowest milk producers in the State. Further investigation of corrective measures applicable to the area and of the effect of copper supplementation on production is necessary.

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QUEENSLAND HOST RECORDS FOR THE DACINAE (fam. *Trypetidae*). FIRST SUPPLEMENTARY LISTS

By A. W. S. MAY, M.Agr.Sc., Senior Entomologist, Science Branch, Division of Plant Industry.

SUMMARY.

Further host records for the Dacinae in Queensland, recorded since the publication of the original host lists in 1953, are tabulated. The data are, in general, presented in the same form, although for convenience the progressive host scores for species are given.

New records are presented for the economic species in Queensland. Strumeta tryoni **(Frogg.) has now been bred from 114 hosts.**

This paper tabulates records obtained since the publication of the original host lists (May 1953), and the data are, in general, presented in the same form. Three new unpublished records, taken from the fruit fly collection of the University of Queensland, are included.

In Section 1, for convenience, the total numbers of hosts recorded for each species are also given, and conform to a pattern—e.g., 2:1:3(+2) denotes 2 commercial, 1 ornamental and 3 wild hosts with 2 further wild host records doubtful or unconfirmed.

New records are presented for the economic species in Queensland. *Strumeta tryoni* (Frogg.), the most important of these, has now been bred from 114 hosts.

Of the five species of Dacinae described (May 1956) during the past three years, hosts of only three are known, while of the 44 species of Dacinae recorded from Queensland, wild hosts of nine are still unknown.

SECTION 1.

Fruit Fly—Host List.

This list contains progressive host scores for 14 genera with 44 species.

AFRODACUS Bezzi.

Afrodacus brunneus Perk. & May.

(0:0:0)

Afrodacus jarvisi (Tryon).

(6:0:4(+1))

Afrodacus mesoniger May.

Wild Hosts.

Lauraceae.

Cinnamomum oliveri F. M. Bail.—Sassafras: December.

Cinnamomum virens R. T. Baker: February.

(0:0:5)

Afrodacus tigrinus May.

(0:0:0)

ASIADACUS Perk.

Asiadacus calophylli Perk. & May.

(0:0:1)

AUSTRODACUS Perk.

Austrodacus cucumis (French).

Commercial Host.

Cucurbitaceae.

Luffa cylindrica Roem. (= *L. aegyptiaca* Mill.)—Vegetable sponge: May—oviposition through scars in rind of near-mature fruits.

(9:0:2(+1))

CALLANTRA Walk.

Callantra aequalis (Coq.).

Wild Host.

Asclepiadaceae.

Marsdenia rostrata R.Br.: March. The larvae feed in the spongy tissues surrounding the central seed cavity. Pupation takes place within the fruits, and the adults emerge after the fruits, which do not fall when ripe, split open to release the kapok-like seeds.

(0:0:1)

Callantra auricoma May.

Commercial Host.

Cucurbitaceae.

Trycosanthes anguina L.—Guada bean: November. No wild hosts have been recorded for this species.

(1:0:0)

Callantra petioliforma May.

(0:0:0)

DACULUS Speis.

Daculus murrayi Perk.

(0:0:1)

DIPLODACUS May.

Diplodacus signatifer (Tryon).

(0:0:1)

HETERODACULUS Hardy.

Heterodaculus visendus Hardy.

Wild Host.

Guttiferae.

Garcinia warrenii F. Muell.—A Native mangosteen: November.

(0:0:2)

MELANODACUS Perk.

Melanodacus niger (Tryon).

(0:0:3)

NEODACUS Perk.

Neodacus newmani Perk.

(0:0:0)

Neodacus signatifrons May.

(0:0:0)

NEOZEUGODACUS May.

Neozeugodacus aglaiae (Hardy).

(0:0:2)

Neozeugodacus aureus May.

(0:0:1)

PARATRIDACUS Shiraki.

Paratridacus expandens (Walk.).

Wild Host.

Guttiferae.

Garcinia gibbsae Sp.Moore—a Native mangosteen: September—quite prevalent in this host.

POLISTOMIMETES Enderlein.

Polistomimetes absonifacies May.

Wild Host.

Asclepiadaceae.

Marsdenia rostrata R.Br.: December. One specimen only was bred from an immature fruit. This species has been recorded frequently in lure traps in South Queensland.

(0:0:1)

STRUMETA Walk.

Strumeta alyxiae May.

(0:0:1)

Strumeta bancroftii (Tryon).

(0:0:1)

Strumeta barringtoniae (Tryon).

(0:0:1)

Strumeta bilineata Perk. & May.

(1:0:3(+1))

Strumeta breviaculeus Hardy.

Wild Host.

Euphorbiaceae.

Glochidion ferdinandii Muell. Arg.: August and November (UQ).

(0:0:2(+1))

Strumeta bryoniae (Tryon).

(0:0:5)

Strumeta cacuminata Hering.

(3:0:3)

Strumeta endiandrae Perk. & May.

Wild Host.

Lauraceae.

Endiandra cowleyana F. M. Bail.: September.

(0:0:6(+1))

Strumeta fagraea (Tryon).

(0:0:3)

Strumeta fuscatus Perk. & May.

(0:0:2(+1))

Strumeta halfordiae (Tryon).

Wild Hosts.

Smilacaceae.

Smilax australis R.Br.—a Wait-a-while: December. Only one specimen was bred from a large collection of fruits.

Myrtaceae.

Eugenia crebrinervis C. T. White—a Water gum: February and March —bred in large numbers.

Rutaceae.

Acronychia pubescens (F. M. Bail.) C. T. White (=*Melicope pubens* F. M. Bail.): December.

Thymelaeaceae.

Phaleria chermsideana (F. M. Bail.) C. T. White: March.

(5:2:11)

Strumeta humeralis (Perk.).

Commercial Hosts.

Annonaceae.

Annona squamosa L.—Custard apple: September—occasional specimens among numbers of *S. tryoni.*

Palmae.

Phoenix dactylifera L.—Date palm: February—a coastal record.

Rosaceae.

Fragaria × *ananassa* Dene. (*F. indica* Andr. of May 1953)—Strawberry: December. This is a chance record from a home garden in Brisbane. The fruits were attacked in the ripe state on plants exhibiting molybdenum deficiency.

Ornamental Host.

Rutaceae.

Casimiroa edulis Llave & Lex.—White sapote: January.

Wild Hosts.

Annonaceae.

Cananga odorata (Lam.) Hook.f. & Thoms.—Ylang-ylang: July (UQ).

Celastraceae.

Elaeodendron australe Vent.: February.

Combretaceae.

Terminalia catappa L.—Tropical almond: February. Large numbers emerged from this host in association with *S. tryoni* and *A. jarvisi.*

Lauraceae.

Endiandra cowleyana F. M. Bail.: September—large numbers in association with *S. endiandrae.*

Myrtaceae.

Eugenia australis Wendl. ex Link (= *E. paniculata* Banks & Sol. ex Gaertn.)—Scrub or creek cherry: February.

Eugenia tierneyana F. Muell.: February—in association with *S. kraussi* Hardy.

Rhodomyrtus macrocarpa Benth.—Finger cherry: September—occasional specimens only.

Rubiaceae.

Nauclea orientalis L. (= *Sarcocephalus cordatus* (Roxb.) Miq.)—Leichhardt tree or canary wood: April. This record was established in South Queensland.

(20:5:20(+1))

Strumeta kraussi Hardy.
Wild Host.

Rutaceae.

Halfordia scleroxyla F. Muell.—Northern saffron heart: October.

H. scleroxyla is closely related to *H. kendack* (Montr.) Guillaum., the type host of *S. halfordiae,* and may prove no more than varietally distinct. The former has reddish fruits and occurs north of Townsville, so far as known, while the latter has bluish fruits and occurs in the subtropics.

(0:2:19)

Strumeta melas Perk. & May.
Commercial Hosts.

Palmae.

Phoenix dactylifera L.—Date palm: February—a coastal record.

Rutaceae.

Citrus sinensis Osbeck—Orange: February—occasional specimens only.

(8:0:2)

Strumeta musae (Tryon).

This species was seen ovipositing in a ripe mandarin (*Citrus reticulata* Blanco) at South Johnstone, North Queensland, but larvae failed to develop.

(2(+1):0:1(+2))

Strumeta mutabilis May.
(1:0:0)

Strumeta notatagena May.
(0:0:0)

Strumeta pallidus Perk. & May.
(0:0:1)

Strumeta phaleriae May.
Wild Host.

Thymelaeaceae.

Phaleria blumei (Dene.) Benth. var. *latifolia* Benth.: June.

(0:0:1)

Strumeta pulcher (Tryon).

(0:0:1)

Strumeta recurrens Hering.

(0:0:1)

Strumeta strigatus (Perk.).

(0:0:0)

Strumeta tryoni (Frogg.).

Commercial Host.

Rosaceae.

Rubus ursinus Cham. & Schlecht. var. *loganobaccus* L. H. Bail.—Loganberry: November. Heavily infested.

Ornamental Host.

Rutaceae.

Casimiroa edulis Llave & Lex.—White sapote: January.

Wild Hosts.

Annonaceae.

Cananga odorata (Lam.) Hook.f. & Thoms.—Ylang-ylang: July (UQ).

Apocynaceae.

Carissa ovata R.Br.—Currant bush: November—a confirmation of record (see May 1953, p. 31).

Lauraceae.

Endiandra cowleyana F. M. Bail.: September—only occasional specimens amongst large numbers of *S. endiandrae* and *S. humeralis.*

Myrtaceae.

Acmena macrocarpa C. T. White—a Water gum: April. A few specimens emerged with large numbers of *S. kraussi.*

Eugenia kuranda F. M. Bail.—Cherry penda: November—a few specimens only.

Vitaceae.

Cissus sp.—A Native grape: December. This undetermined host, collected near Toowoomba, is distinct from *C. antarctica* Vent.

(41:10:63(+3))

ZEUGODACUS Hendel.

Zeugodacus atrisetosus Perk.

(0:0:1)

Zeugodacus synnephes (Hendel).

(0:0:1)

SECTION 2.

HOST—FRUIT FLY LIST.

Botanical Name.	Common Name.	Species Recorded.	Remarks.
ANNONACEAE			
Annona squàmosa L. . .	Custard apple . .	*Strumeta humeralis*	Occasional specimens.
Cananga odorata (Lam.) Hook.f. & Thoms. . .	Ylang-ylang . .	*Strumeta humeralis*	
		Strumeta tryoni . .	
APOCYNACEAE			
Carissa ovata R. Br. . .	Currant bush . .	*Strumeta tryoni* . .	A confirmed record. (See p. 35).
ASCLEPIADACEAE			
Marsdenia rostrata R. Br.		*Callantra aequalis* . .	
		Polistomimetes absonifacies . .	From immature fruit.
CELASTRACEAE			
Elaeodendron australe Vent.		*Strumeta humeralis*	
COMBRETACEAE			
Terminalia catappa L.	Tropical almond . .	*Strumeta humeralis*	
CUCURBITACEAE			
Luffa cylindrica Roem.	Vegetable sponge . .	*Austrodacus cucumis*	
Trycosanthes anguina L.	Guada bean . .	*Callantra auricoma*	
EUPHORBIACEAE			
Glochidion ferdinandii Muell. Arg.		*Strumeta breviaculeus*	
GUTTIFERAE			
Garcinia gibbsae Sp. Moore	A Native mangosteen	*Paratridacus expandens*	
Garcinia warrenii F. Muell.	A Native mangosteen	*Heterodaculus visendus*	
LAURACEAE			
Cinnamomum oliveri F. M. Bail.	Sassafras	*Afrodacus mesoniger*	
Cinnamomum virens R. T. Baker		*Afrodacus mesoniger*	
Endiandra cowleyana F. M. Bail.		*Strumeta endiandrae*	In large numbers.
		Strumeta humeralis	In large numbers.
		Strumeta tryoni . .	Occasional specimens.
MYRTACEAE			
Acmena macrocarpa C. T. White	A Water gum . .	*Strumeta tryoni* . .	Occasional specimens.
Eugenia australis Wendl. ex Link	Scrub or creek cherry (Creek lilly pilly)	*Strumeta humeralis*	
Eugenia crebrinervis C. T. White	A Water gum . .	*Strumeta halfordiae*	Usually infested.
Eugenia kuranda F. M. Bail.	Cherry penda . .	*Strumeta tryoni* . .	Occasional specimens.

HOST—FRUIT FLY LIST—*continued.*

Botanical Name.	Common Name.	Species Recorded.	Remarks.
MYRTACEAE—*continued*			
Eugenia tierneyana F. Muell.		*Strumeta humeralis*	
Rhodomyrtus macrocarpa Benth.	Finger cherry ..	*Strumeta humeralis*	Occasional specimens.
PALMAE			
Phoenix dactylifera L.	Date palm	*Strumeta humeralis*	A coastal record.
		Strumeta melas ..	A coastal record.
ROSACEAE			
Fragaria × *ananassa* Dcne.	Strawberry	*Strumeta humeralis* ..	Ripe fruit attacked. (See p. 33).
Rubus ursinus Cham. & Schlecht. var. *loganobaccus* L. H. Bail.	Loganberry	*Strumeta tryoni* ..	Heavily infested.
RUBIACEAE			
Nauclea orientalis L. ..	Leichhardt tree ..	*Strumeta humeralis*	
RUTACEAE			
Acronychia pubescens (F. M. Bail.) C. T. White		*Strumeta halfordiae*	
Casimiroa edulis Llave & Lex.	White sapote ..	*Strumeta humeralis*	
		Strumeta tryoni	
Citrus reticulata Blanco	Mandarin	*Strumeta musae* ..	Ovipositing only.
Citrus sinensis Osbeck	Orange	*Strumeta melas* ..	Occasional specimens.
Halfordia scleroxyla F. Muell.	Northern saffron heart	*Strumeta kraussi* ..	
SMILACACEAE			
Smilax australis R. Br.	A Wait-a-while ..	*Strumeta halfordiae*	One specimen only.
THYMELAEACEAE			
Phaleria blumei (Dcne.) Benth. var. *latifolia* Benth.		*Strumeta phaleriae* ..	
Phaleria chermsideana (F. M. Bail.) C. T. White		*Strumeta halfordiae*	
VITACEAE			
Cissus sp.	A Native grape ..	*Strumeta tryoni* ..	

Fig 1.

Alyxia spicata R.Br. (a Chain-fruit), the Host of *Strumeta alyxiae* May.

Fig. 2.

Terminalia muelleri Benth., a Wild Host of *Strumeta tryoni* (Frogg.)

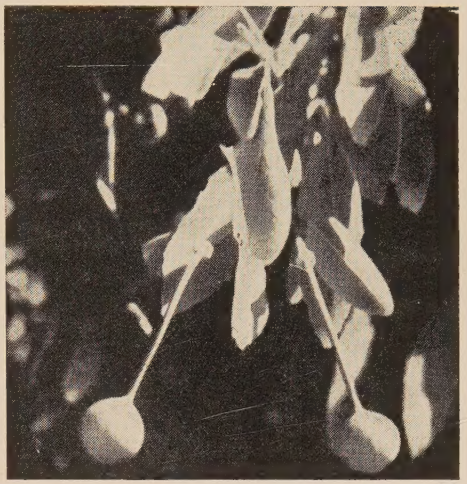

Fig. 3.

Capparis lucida (DC.) R.Br. ex Benth., the Only Known Host of *Diplodacus signatifer* (Tryon).

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A. H. Tucker, Government Printer, Brisbane.